FORESTRY

FRDA REPORT 115

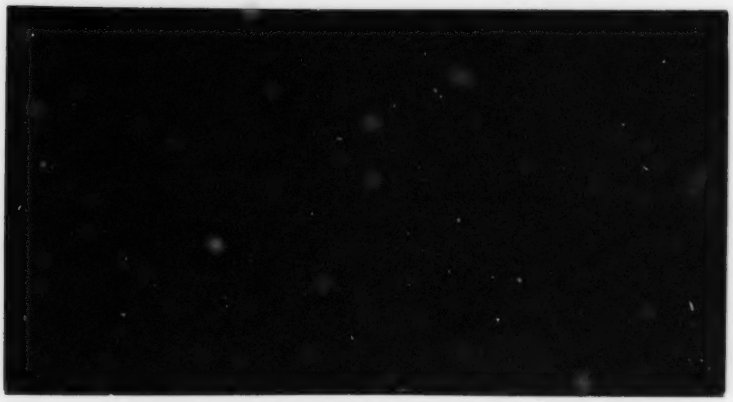
CURRENT BIOMASS STATUS OF RED ALDER IN COASTAL BRITISH COLUMBIA

by
M.R.C. Massie, R.P.F.

FOREST RESOURCE DEVELOPMENT AGREEMENT

Canada

BC



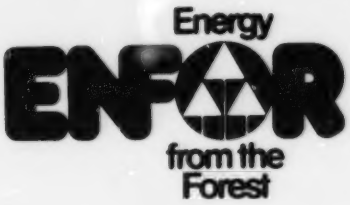


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TABLE OF CONTENTS

		Page No.
1.	INTRODUCTION	1
2.	INVENTORY	2
2.1	Previous Volume Estimates	2
2.2	Current Estimates	4
2.3	Inventory Information Gaps	9
3.	MANAGEMENT	10
3.1	Ecology and Tree Physiology	10
3.2	Silvics and Regeneration	11
3.3	Growth and Yield	12
3.4	Soil Improvement and Nitrogen Fixation	14
3.5	Red Alder Control and Conversion	16
3.6	Protection	17
3.7	Additional Management Information Needs	17
4.	UTILIZATION	19
4.1	Past Alder Utilization in B.C.	19
4.2	Utilization in Washington and Oregon	19
4.3	Literature Summary	20
4.4	Current Utilization in B.C.	22
4.5	Utilization Information Gaps	25
5.	ENERGY POTENTIAL AND WASTE	27
5.1	Biomass	27
5.2	Biomass Energy Potential	27
5.3	Waste Energy Potential	28

LITERATURE CITED

ADDITIONAL REFERENCES

APPENDICES

CURRENT BIOMASS STATUS OF RED ALDER IN COASTAL BRITISH COLUMBIA

1. INTRODUCTION

This brief report brings together and reviews information concerning the red alder (Alnus rubra Bong.) resource in Coastal British Columbia. The literature review concentrates mainly on the last 12 years, but some major earlier works were included where pertinent. A variety of public and private sources were consulted to identify the current status of inventory information, management information and the utilization situation. Future information needs and research are suggested and discussed.

Some tables and information that may be useful in defining the status of the resource have been referenced and included in the Appendix.

2. INVENTORY

The distribution of alder on the west coast of North America is shown in Figure 1, and more particularly for Coastal B.C. in Figure 2.

Red Alder is a coastal species usually occupying moist site forest land within 100 miles (161 km) of salt water. The north-south range is from Alaska above the panhandle (about 60^{o} latitude) to well down into California (about 30^{o} latitude). Elevation is usually limited to below 2500 feet (760 metres).

2.1 PREVIOUS VOLUME ESTIMATES

The 1972 Forest Inventory of B.C. gives estimates for alder on the B.C. Coast. These estimates are summarized in Table 1. They indicate the total volume of alder in both pure and mixed stands. The figures are useful to show the broad picture at that time. Note the differences between the north and south coast and in ownership.

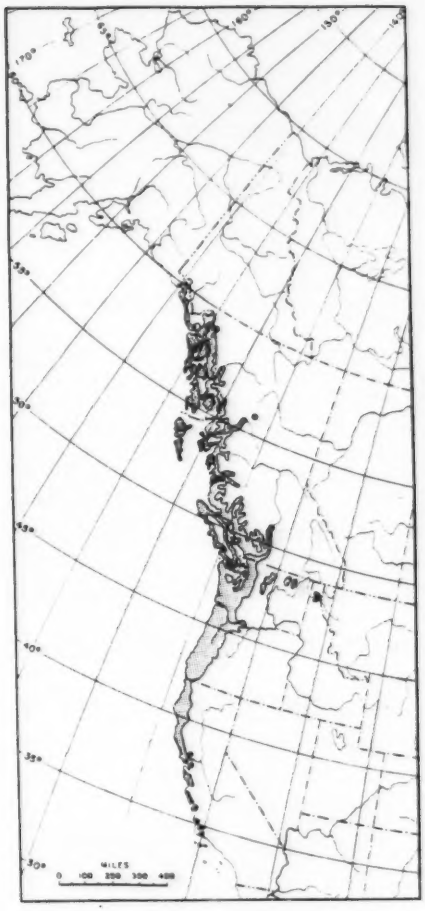
Table 1. Summary of 1972 Volumes of Alder on the B.C. Coast[1] (000 m3)

	Crown Lands in PSYU	Crown Lands in TFL	Other & Private	All Lands
North and Mid Coast and Q.C. Islands	2,296	391	329	3,016
South Coast or Vancouver Region	756	5,485	4,035	10,276
Total	3,052	5,876	4,364	13,292

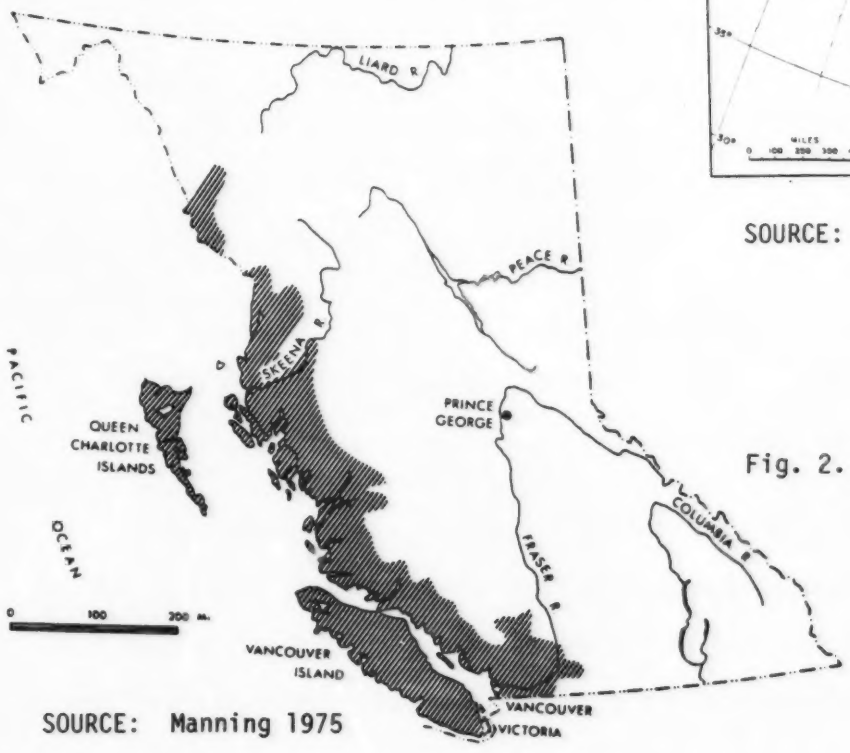
1. Alder volumes in both pure and mixed stands for trees having a dbh of 17.5+

SOURCE: 1972 Inventory Statistics of B.C. Ministry of Forests, Inventory Branch, Victoria.

Fig. 1 Range of red alder



SOURCE: USDA 1965



SOURCE: Manning 1975

Fig. 2. Distribution of red alder in B.C.

In order to support increased utilization, better or more detailed statistics are required. Some of these statistics can be derived from updated inventory information, particularly the information compiled to expedite the 1984 Resource Analysis. The following tables further clarify the mature and immature components of the resource and report on the basis of the pertinent nine timber supply areas as of 1984. Further, they provide site information, a first breakdown of pure and mixed stands and an indication of the hectares of forest land involved.

2.2 CURRENT ESTIMATES

Tables 2 to 4 indicate volumes in more or less pure alder stands in total and on Crown and private land. Note that an age definition (80 years or more) is used to define mature. This is not very useful for utilization purposes because 80 year or more old alder can be past its prime for many products.

Similarly, it is not a good indicator of availability of merchantable wood because many of the stands could have been lost at this age. In essence, a new immature stand is in progress or conversion to another species is in progress.

The tables do show, however, on a volume basis an estimate of pure stands in relation to supply areas, site and ownership.

Table 5 gives broad estimates of the hectares of pure alder stands on the B.C. coast. These estimates should be used with caution as relatively small changes in forestry practices and definitions can significantly change the estimates. As presented, they are believed to be conservative.

Table 2. Alder Stands on Crown Land, Coast B.C. (000 m3)

SUPPLY AREA	GOOD		MEDIUM		POOR	
	Mature	Immature	Mature	Immature	Mature	Immature
North Coast	48	36	71	99	35	163
Q. Charlotte Is.	0	1	28	36	10	104
Kalum	7	6	9	6	1	2
Kingcome	19	171	235	725	16	394
Quadra	12	147	100	1,163	11	506
Fraser	7	38	42	208	1	183
Mid-Coast	49	28	74	127	18	111
Soo	3	9	19	42	3	29
Nootka	6	0	3	139	4	45
Total Coast	151	436	581	2,545	99	1,537

Table 3. Alder Stands on Private and Other Ownerships, Coast B.C. (000 m3)

SUPPLY AREA	GOOD		MEDIUM		POOR	
	Mature	Immature	Mature	Immature	Mature	Immature
North Coast	2	1	2	3	1	5
Q. Charlotte Is.	0	0	2	3	1	8
Kalum	2	2	3	2	0	1
Kingcome	4	33	45	139	3	76
Quadra	17	209	142	1,654	16	721
Fraser	15	79	87	434	2	382
Mid-Coast	5	3	7	12	2	11
Soo	1	4	8	18	1	12
Nootka	2	0	1	49	1	16
Total Coast	48	331	297	2,314	27	1,232

Table 4. Alder Stands on the B.C. Coast, All Ownerships (000 m3)

SUPPLY AREA	GOOD		MEDIUM		POOR	
	Mature	Immature	Mature	Immature	Mature	Immature
North Coast	50	37	73	102	36	168
Q. Charlotte Is.	0	1	30	39	11	112
Kalum	9	8	12	8	1	3
Kingcome	23	204	280	864	19	470
Quadra	29	356	242	2,817	27	1,227
Fraser	22	117	129	642	3	565
Mid-Coast	54	31	81	139	20	122
Soo	4	13	27	60	4	41
Nootka	8	0	4	188	5	61
Total Coast	199	767	878	4,859	126	2,769

Table 5. Estimate of Areas of Alder Stands on the B.C. Coast (hectres)

SUPPLY AREA	CROWN LAND		PRIVATE & OTHER		ALL OWNERSHIPS	
	Mature	Immature	Mature	Immature	Mature	Immature
North Coast	908	2,682	28	87	936	2,769
Q. Charlotte Is	252	1,571	17	112	269	1,683
Kalum	93	195	30	64	123	259
Kingcome	855	7,432	162	1,423	1,017	8,855
Quadra	453	9,783	644	13,918	1,097	23,701
Fraser	181	2,983	379	6,220	560	9,203
Mid-Coast	819	2,551	78	248	897	2,799
Soo	92	781	39	329	131	1,110
Nootka	146	1,065	19	377	165	1,442
Total Coast	3,799	29,043	1,396	22,778	5,195	51,821

1. Estimates are for stands classified as alder only. Does not include mixed stands, either coniferous or deciduous, where alder is not the lead species. Based on inventory data apportionment, 1984.

Table 6 gives some indication of the resource in mixed stands as well as pure stands. Regrettably, only data concerning "mature" alder are available. Thus, the table has severe limitations in any application concerning utilization as most of the resource best suited to utilization and manufacture could be in the "immature" classification.

How much "immature" alder is in mixed stands then becomes a very important question. Data are not currently available to answer this question but there is no doubt that the figure will be large and significant if one considers that many conifer sites were converted to alder by past logging.

Table 6. Mature Alder in Pure Stands and Mixed Stands, by Major Owherships, B.C. Coast (000 m3)

SUPPLY AREA	CROWN LAND			PRIVATE & OTHER LANDS			ALL OWNERSHIPS		
	Pure	Mixed	Total	Pure	Mixed	Total	Pure	Mixed	Total
North Coast	154	1,087	1,241	5	36	41	159	1,123	1,282
Q.Charlotte Is	38	398	436	3	29	32	41	427	468
Kalum	17	17	34	5	6	11	22	23	45
Kingcome	270	419	689	52	80	132	322	499	821
Quadra	123	329	452	175	468	643	298	797	1,095
Fraser	50	215	265	104	447	551	154	662	816
Mid-Coast	141	730	871	14	71	85	155	801	956
Soo	25	71	96	10	30	40	35	101	136
Nootka	13	150	163	4	53	57	17	203	220
Total Coast	831	3,416	4,247	372	1,220	1,592	1,203	4,636	5,839

1. Tables 1 to 5 are based on 1984 Resource Analysis data and inventory data provided by Inventory Branch, MOF, Victoria. The compilations were provided by FORGIS Consultants, Victoria.

2. Supply Areas: See current map overshaded with older "Quadra" and "Nootka" supply area designations.

If much of the immature alder in pure stands resulted mainly from logging and not fire, natural succession, etc., then many times as much are likely on sites where the attempt to establish conifers was not a complete failure but partially successful and a mixed stand resulted.

The State of Oregon faced with a similar situation has estimated that their alder growing stock is 78% in mixed stands and 22% in pure stands. On this basis the immature alder in mixed stands in B.C. would be something of the order of magnitude of 30 million m^3. A similar order of magnitude would result if one assumed the ratio of mature to immature in pure stands was the same in mixed stands.

CASSIAR T.S.A.
FORT NELSON T.S.A.
ALASKA
2
KALUM
MACKENZIE T.S.A.
FORT ST. JOHN T.S.A.
KISPIOX T.S.A.
4
DAWSON CR. T.S.A.
BULKLEY T.S.A.
T.S.A.
NORTH COAST T.S.A.
HORICE T.S.A.
LAKES T.S.A.
PRINCE GEORGE T.S.A.
QUEEN CHARLOTTE T.S.A.
ROBSON VALLEY T.S.A.
QUESNEL T.S.A.
MID-COAST T.S.A.
WILLIAMS LAKE T.S.A.
6
1
GOLDEN T.S.A.
100 MILE HOUSE T.S.A.
3
KINGCOME T.S.A.
LILLOOET
KAMLOOPS T.S.A.
SOO T.S.A.
5
INVERMERE T.S.A.
OKANAGAN T.S.A.
MERRITT
ARROW T.S.A.
FRASER T.S.A.
CRANBROOK T.S.A.
KOOTENAY LAKE T.S.A.
BOUNDARY T.S.A.
Nootka
Quadra

2.3 INVENTORY INFORMATION GAPS

In order to support the utilization of the alder resource, additional inventory and inventory related information is required. On the private side, in order to log, transport, manufacture and ship alder products, more precise information at a more local level is necessary concerning stand merchantability and quality as well as location and accessibility.

On the public side, more information on the resource is required to plan the best use and allocation of the resource. This would include growth and yield information, age class distributions and stocking information that will be required to plan utilization levels and set annual allowable cuts.

3. MANAGEMENT

3.1 ECOLOGY AND TREE PHYSIOLOGY

A major early report was the result of the Biology of Alder Symposium at Pullman, Washington in 1967. Topics included taxonomy, ecology, soils, physiology and some growth and yield.

DeBell and Wilson (1978) at the 1977 symposium at Ocean Shores, Washington discuss provenance trials for alder in Washington from ten sources including Alaska, British Columbia, Washington, Oregon and Idaho. After eight years differences in growth rates and frost resistance were noticeable. Lester and DeBell (1989) reported on the provenances some ten years later, noting that there was significant variation in height growth, diameter growth and bole volume.

Gordon (1978) presents arguments that alder is an improvable plant material for intensive forestry and Stettler (1978) indicates that the biological aspects of alder are amenable and pertinent to breeding programs and that large genetic gains can be expected. He suggests three thrusts: short rotations for fibre, normal rotations for sawlogs and a nitrogen fixing regime to support conifer production. Perinet and Tremblay (1987) report that clonal micropropagation is commercially feasible for red alder.

DeBell et al (1978) at the same symposium, outlined possible short rotation options on better sites. The shortest rotation would involve a coppice system to produce "barky chips". Next was a pulpwood regime. This was followed by a pulpwood/sawlog and finally a sawlog/peeler log regime. This work is referenced to previous work by Smith and DeBell (1973) who looked at the opportunities for short rotations for several Pacific Northwest trees. Zavitkovski et al (1979) concentrated on nitrogen fixing

species in short rotation systems and their potential for fibre and energy production.

Heilman and Stettler (1983) and (1985) propose short rotation culture of red alder and black cottonwood clones with close spacing. They found cottonwood was generally best by itself and that in mixed regimes cottonwood would outgrow the alder.

Harrington and DeBell (1985) experimented with coppicing alder and cottonwood and irrigation with pulpmill sludge. Cottonwood did best and growth was improved by the sludge. Alder did not respond well to the sludge.

Work on the variation in the specific gravity of red alder is reported by Harrington and DeBell (1980) and they note uniformity between ages and locations. Other physiology related work include DeBell and Radwan (1983) who looked at foliar chemical concentrations in red alder stands of various ages, and Pezeshki and Hinckley (1988) who documented drought responses for black cottonwood and red alder. Cottonwood was best at stomatal closure and leaf loss mainly occurred with alder.

3.2 SILVICS AND REGENERATION

A general discussion of the silvics of red alder is given by USDA (1965). Bergstrom (1979) discusses the capabilities of red alder in managed forests. Regeneration of red alder is covered by Kenady (1978) who reports ease of regeneration. He notes planting stock can easily be produced in nurseries and that plantations where reported appear to have done well. More work and research in this area would be prudent as the information is scanty.

Radwan and DeBell (1981) looked at the germination of alder seed across the species range and found good germination but considerable variation. They, as Kenady above, indicate seed stratification is not necessary. Elliot and Taylor (1981a) reported that the fertility and physical characteristics of the soil were important in early development of seedlings. They also (1981b) reported on germination of alder from several locations, indicating germination was high and that dormancy was not a significant factor. Monaco et al. (1980) reported on rooting cuttings and Borman (1983) covered further technical aspects of germination. Berry & Torrey (1985) covered container seedling production with nodules and Stowers and Smith (1985) and Sugihara (1984) discuss inoculation of container seedlings. Trembley and Lalande (1987) investigated frost hardiness and the effect of photoperiod and temperature and Sheppard et al. (1988) conducted greenhouse experiments on growth in various soils following inoculation. Radwan (1987) reported on fertilizing red alder seedlings.

3.3 GROWTH AND YIELD

Hegyi et al (1979) discusses total height (metres) and total age with a reference to age 100. Site classifications are given for age 100 and age 50. A following major work by Harrington and Curtis (1986) combined new data with that of Johnson and Worthington (1963) to denote height growth and site index curves for red alder. This research considers site index based on a reference age of 20 years. Mitchell and Polsson (1988) drew on this work to develop site curves and a site index table for red alder in British Columbia for inclusion in their report on coastal species.

Harrington (1986) has also developed a method of site quality evaluation for red alder based on fourteen soil-site properties.

Worthington et al (1960) compiled Normal Yield Tables for Red Alder based on 428 sample plots in Western Washington, Northwest Oregon and Southwest British Columbia. Smith (1978) reported on growth and yields in British Columbia with particular reference to stand density.

Chambers (1974) published a major work, Empirical Yield Tables for Predominately Alder Stands in Western Washington which has been reprinted several times; most recently in 1983. This sound empirical work is all the more valuable because it considers a variety of stand densities rather than just variable density. It appears to be applicable to Southwest British Columbia.

Curtis et al (1968) developed volume and taper tables based on 473 trees from Oregon, Washington and British Columbia, and an individual tree volume table showing gross merchantable in m^3 was developed by Demaerchalk and Kozak (1977).

Bernsten (1961) found that pruning will improve lumber quality but only if epicormic branching can be controlled. DeBell et al (1978) found that alder could be aged correctly by ring counts using cross-sections.

Stubblefield and Oliver (1978) make silvic recommendations with particular reference to alder and conifer stands and Borman (1985) reports growth and stem form from early wide spacing of alder. Hook et al (1987) reports growth variation in alder according to water table.

Smith and Hann (1984) and Hibbs (1987) report on the self-thinning rule for alder and implications for alder management. Hibbs and Carlton (1989) compare diameter and volume based stocking guidelines and conclude that density management prescriptions are not likely to be uniform. Hibbs et al (1989) report on their recent thinning experiment where thinning a 14 year stand both chemically and manually decreased height but increased diameter. The first 5-year results indicate no significant volume increase.

3.4 SOIL IMPROVEMENT AND NITROGEN FIXATION

Considerable work has been done on alder and nitrogen fixation. Much of this involves improving the growth of conifers. In this section technical details are discussed first and applications second.

Technical Considerations

Tripp et al (1979) relates the rate of nitrogen fixation in young alder stands to seasonal and diurnal patterns. DeBell and Miller (1979) show that N_2 fixing systems are different from fertilization. Binkley (1981) shows that Sitka alder which might be more attractive for use in forest management because of its shrub-like nature has a substantial fixation rate, but less than red alder.

Bormann and DeBell (1981) indicate that young alder stands rapidly fix nitrogen, but as age increases fixation declines to a nearly constant accumulation. Radwan and DeBell (1982) indicated that N and P in the forest floor are related to the age of the alder stand, and DeBell et al (1983) indicate as N accumulates with age other chemicals in the soil can

decrease or increase. Bormann and Gordon (1984) indicate high density stands provide less fixation.

Litter production, accumulation, and decomposition relate to the fixation process. Various aspects of relationships in these areas have been reported on by Zavitkovski and Newton (1971), Edmonds (1980), Heilman and Ekuan (1982), Luken and Fonda (1983), Heilman (1982), Radwan et al (1984), Miegroet and Cole (1985) and Edmonds (1987).

Neaves (1978) discusses litter fall in a watershed, and Edmonds et al (1986) discuss decomposition of Douglas fir and red alder wood in clear-cuts. The potential for nitrogen fixation in forest management is discussed by Tarrant and Trappe (1971) and Gordon and Dawson (1979).

Applications In Forest Management

Bernsten (1961) reports on the growth and development of alder with conifers, and the beneficial effects of alder on the growth of Douglas fir were reported by Miller and Murray (1978) and Cole (1978). DeBell and Radwan (1979) reported on alder and cottonwood.

Binkley (1983, 1984) discusses alder effects on Douglas fir plantations and the importance of size-density relationships. Tarrant et al (1983) consider the Net Present Worth of alder/fir management versus fertilization, as did Atkinson and Hamilton (1978). Atkinson et al (1979) indicated biological and economic potential but a more costly investment than fertilizer. Miller and Murray (1979) discussed fertilizer rates and costs in relation to red alder fixation. In general, it appears fertilizing still has considerable merit, especially if application costs are relatively low.

Binkley (1984a) reports on Douglas fir stem growth per unit of leaf area as increased by interplanted red or Sitka alder, and the importance of size-density relationships in mixed stands (1984b). Murray and Millar (1986) reported on early survival and growth of interplanted Douglas fir and red alder. Cole and Newton (1986) indicated that Douglas fir can be crowded by alder and growth can decrease.

3.5 RED ALDER CONTROL AND CONVERSION

Yoho et al (1969) provide an early discussion of the economics of converting red alder to Douglas fir. At the 1978 symposium Waggener (1978) provided another analysis concluding that replacement is feasible under certain conditions, particularly if alder management was the alternative.

Randall (1978) concluded conversion was feasible if adequate coniferous stocking was obtained.

Newton (1978) reports on the use of herbicides in alder control and management and discusses major chemicals, procedures and timing. Warren et.al. (1984) report on alder control using several chemicals. Hibbs and Landgren (1987) report on the "thin line" application of herbicide which wets one side of small stems. Harrington (1984) reports on factors influencing alder sprouting, and DeBell and Turpin (1989) discuss guidelines for manual cutting in Douglas fir plantations.

Reynolds (1988) gives a prognosis for future forestry herbicide use in Canada including the status of current chemicals and possible future chemicals. Recently, Lousier et al (1989) are reporting to Research Branch of the Ministry of Forests on their FRDA project, which looks into controlling the spread of streamside alder (valuable for stream habitat) into adjacent harvested clearings.

3.6 PROTECTION

Very little work relative to other species has been conducted on diseases and insect pests with respect to alder. Gara and Jaeck (1978) indicate little research is in progress on insect problems and that defoliators could be a threat if management of the species increases. Driver (1978) comments little is known on diseases with respect to management. He is particularly concerned with the decadence or die-back that sometimes occurs at about age 40. Nelson et al (1978) indicates long term plots have been established to ascertain if an alder mix with conifers will assist in combating laminated (Phellinus) root rot. Hawksworth & Scharpf (1984) indicate red alder hosts European mistletoe in California. Nijholt (1988) reports on the problem of Ambrosia beetles in alder.

Meyers and Williams (1984) discuss tent caterpiller attack and the food quality of red alder foliage, and Moore et. al. (1988) indicate tent caterpillar preference for the south facing part of the tree. Williams and Myers (1984) discuss defoliators improving food quality for fall webworm on red alder.

3.7 ADDITIONAL MANAGEMENT INFORMATION NEEDS

In general, information is lacking on managing second growth alder as a forest crop in both pure stands and in a mixture with conifers. Some work has been done on stand density, but gaps are noticeable in both natural and artificial regeneration, stand tending relative to growth rates and forest product objectives, and yields under managed and treated conditions. Very few thinning trials have been conducted in pure alder, and thinning or spacing of alder and conifers with the objective of managing both species in combination has not been dealt with.

Some regeneration research has been done and some seedling culture and development, but in general it is very limited. More work in this area is needed as well as follow through into planting techniques and trials.

The whole area of protection with particular reference to insects and disease has only very minor coverage. Little is known on what hazards exist in this area if managed second growth alder stands in pure or mixed form are promoted.

The role of alder in pure or mixed stands with respect to fire hazard and protection is noticeably absent from the literature. Some alder stands have been used as fire breaks on private forest land in the dry Douglas fir belt on Eastern Vancouver Island. Alder stands are frequently used as a buffer zone along streams and small lakes, but little information is generally available on whether these areas could also be managed in part or for both habitat protection and timber production.

4. UTILIZATION

4.1 PAST ALDER UTILIZATION IN B.C.

Nielson (1977) and MacPherson (1980) reported on alder utilization in the late 1970s. Nielson indicates a merchantable mature volume of 13.2 million m^3 on the B.C. Coast. He reports that most of the volume (10.2 million m^3) is on Tree Farm Licences and private land. The harvest of Coast alder and maple (mainly alder) in the early 1970s was about 50 to 60,000 m^3 annually, and there was one active hardwood sawmill. The annual allowable cut was roughly estimated at 270,000 m^3.

At the symposium held in Prince George in 1979 A.C. MacPherson (Regional Manager, Vancouver Forest Region) reported the latest estimates concerning alder on the B.C. Coast. Mature volumes were estimated at 8 million m^3. In the Vancouver Region (South Coast) 1 million m^3 was on Crown land, 1 million in the Tree Farm Licences and 3.7 million m^3 on private land. In the Prince Rupert Region (North Coast) 2 million m^3 was on Crown land and 0.3 million m^3 on Tree Farm Licences and private land. In 1978 the harvest was about 10,700 m^3 down from a high of 69,600 m^3 in 1974. Three small hardwood sawmills were operating in 1978.

4.2 UTILIZATION IN WASHINGTON AND OREGON

Little (1978) reports that 10 percent of the commercial forest land in Washington is hardwood, mainly alder. These 1.8 million acres support an estimated 12 billion board feet of alder in mixed stands with a lessor coniferous component, and an estimated 7.1 billion board feet in pure hardwood stands, mainly alder. The harvest is about 300 million board feet

annually and is expected to climb to about 700 to 800 million board feet in the late 1980s.

Baack (1989) reports that 1.1 million acres in Oregon are alder timberland and the inventory is 3.1 million cubic feet or about 11.3 billion board feet. The harvest is about 181 million board feet for hardwoods not including firewood. Most but not all is alder. About 108 million board feet are manufactured within the state and 73 million board feet exported as chips.

4.3 LITERATURE SUMMARY

In the late 1970s estimates concerning the alder resource were developed for Washington (Little 1978) and for Oregon (Bassett 1979; Mei 1979). B.C. estimates were provided by Nielson (1977) and MacPherson (1980). A more comprehensive report was given by Poppino and Gedney (1984) for Oregon a few years later. Just recently Baack (1989) has published a detailed report on the Oregon alder resource, its utilization and contribution to the state economy.

Early U.S. reports discussed the growing of alder (Doran et al 1971; Atterbury 1978) and discussed problems concerning marketing and utilization (Feddern 1978; Behm 1978; Briggs and Bethel 1978). Many technical reports directed at specific utilization problems appeared in conjunction with the 1977 symposium. Fye and Briggs (1978) discussed grading rules, Kozlick (1978) discussed colour with particular reference to drying alder. Remington (1978) comments on the potential for pulpchips when sawing alder. Maloney (1978) points out the potential for composite board and Hrutfiord (1978) outlines pulping potential and applicability of whole tree chipping.

In B.C. Demaerschalk and Kozak (1977) published an individual tree volume table for red alder, and at the 1979 symposium Nielson (1980) discussed challenges concerning secondary and minor products made from alder. Mackay (1980) addressed kiln drying of hardwoods and alder. Danylchuk (1980) summarized the current alder utilization in B.C. and future possibilities.

In the early 1980s in the Pacific Northwest, interest increased in alder utilization and Resch (1980) pointed out the merits of increased utilization rather than stand conversion to coniferous species based on significant value added. McGillivray (1981) followed with a comprehensive report on barriers to alder utilization and details concerning product specifications, shipping costs and competition.

Toovey (1980) pointed out that increased utilization of alder in B.C. was impeded by several factors ranging from lack of inventory to market acceptance. Interest in alder did not increase in B.C. and in the Vancouver Forest Region stand conversion to conifers was an accepted program (Kennah, 1987).

Further technical considerations in alder utilization were addressed by Bastendoff and Polensek (1984) in pallet manufacture and high temperature drying of boards (Kozlick and Boone, 1987) and lumber stain control (Morrell, 1987).

Govett et al (1987) and Ackerman (1987) looked at overseas markets for U.S. hardwoods and the domestic outlook for solid and composite products in furniture and cabinets. Briggs and Buhler (1989) discuss the importance of alder in the economy of the Pacific Northwest and the role of international

trade. Baack (1989) gives a detailed description of the important role alder plays in the economy of Oregon.

4.4 CURRENT UTILIZATION IN B.C.[1]

The harvesting of alder has been erratic over the past several years. In addition volumes being extracted from private lands are not well documented and include both firewood and lesser volumes of industrial wood. Based on limited information provided by firms using alder, the industrial harvest is broadly estimated to be between 130,000 and 150,000 m^3 in 1989.

Some alder logs are exported, but statistics are reported only on a total hardwood basis. While most exports of hardwood logs from B.C. ports originate in B.C., a large part of the hardwood logs are cottonwood or aspen destined for the Peoples Republic of China. All hardwood logs exported from B.C. in 1987 were about 93,000 m^3 and in 1988 about 150,000 m^3. In 1987 hardwood lumber amounted to some 23,000 m^3 on a solid wood basis.

At the start of 1990 only two companies on the south coast of B.C. held a quota position in alder. The Ministry of Forests 1990 Apportionment indicates the following temporary AAC (non-replaceable Forest Licences) are in effect:

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1. Much of the information in this section was compiled by R.M. (Dick) Herring, R.P.F., an Associate of Stewart & Ewing Associates Ltd., Richmond, B.C.

Company	AAC Volume	TSA	Expire Date
Discovery Hardwoods Ltd.	4,000 m3	Arrowsmith	Aug 3, 2001
Box 3460	20,000 m3	Kingcome	Aug 3, 2001
Courtenay, B.C. V9N 5N5	16,000 m3	Strathcona	Aug 3, 2001
(Location: Menzies Bay)	16,000 m3	Sunshine Coast	Aug 3, 2001
	56,000 m3		
Norvik Timber Inc. 7515 Hopcott Road Delta, B.C. V4G 1B7 (Location: Tilbury Island)	65,000 m3	Fraser	Dec 31, 2008

Two other companies operate in south coastal B.C. Coastland Wood Industries in Nanaimo and Primex Forest Products Ltd. which has mills in Delta and Courtenay. The Primex mills are both softwood sawmills, but alder is chipped at the Delta site. The Coastland Wood Industries mill is a veneer mill which peels mainly fir but also small amounts of alder. A chip mill is located adjacent to the veneer mill and is presently chipping alder logs and alder peeler cores.

Discovery Hardwoods sawmill cuts select and No. 1 alder boards for export to the U.S. Currently the production is shipped green to the U.S. but kiln capacity is being installed. Lesser quality logs and alder cuttings are chipped. Planned capacity is 50 M fbm per shift. Alder chips are sent to Fibreco in North Vancouver for export to C. Itoh Co. in Japan. The alder chip mill has an annual total capacity of about 200,000 m^3 but only produced 50,000 to 60,000 BDU in 1989.

The companies log supply consists of the previous AAC volumes and is supplemented with local purchases.

Coastland Wood Industries operates a veneer mill having a shift capacity of 230 K sq. ft. 3/8" basis or about 110 MM square feet annually. Log consumption (mostly D. fir) is about 280,000 m^3 per annum. Currently, alder varies between 2 and 6 percent of production. Further increases are dependent on market development. Current alder veneer production is trucked green to the U.S. The mill operates on local purchasing and most of its supply comes from private land. Chips are sent to Cowichan Bay by truck for barging to Fibreco in North Vancouver and then to C. Itoh Co. in Japan.

Primex Forest Products saws softwoods, but operates a chip mill at Delta that chipped alder in 1989. Total 1989 production was about 105,000 BDU and was exported by ship to Japan. The mill has no firm source of supply for alder logs and has currently ceased production pending improved alder chip prices.

Norvik Timber is testing the cutting of alder in their Tilbury mill (previous BCFP mill purchased from Fletcher-Challenge Canada). About 50 M fbm can be cut per shift and drying tests are being conducted. Current production is being sold green to the U.S. Engineering studies on mill improvements are in progress and cutting alder on a regular basis is being considered. A chip mill is planned adjacent to the sawmill. As mentioned above the company holds a quota of 65,000 m^3 annually in the Fraser TSA. A logging division is being planned for quota utilization but considerable private wood purchasing is also contemplated. Markets for production are under development.

A few local sawmills operate intermittently on the lower mainland and Vancouver Island. These mills cut local products such as pallet stock from

alder. Total alder log usage is broadly estimated to be 2,000 to 5,000 m^3 annually.

No statistics are available on firewood production. Gemmell, et. al. (1981) estimated a total demand for south Vancouver Island of some 64,000 cords in 1981 rising to 119,000 cords in 20 years. Only part of this volume was alder and a large component is believed to be coniferous logging and mill waste.

Very little if any alder chips are used for pulp production in B.C. There are, however, large markets for alder chips in the U.S. northwest as well as overseas. Companies in B.C. are well aware of these markets and the prices being paid for alder chips. Should these prices advance there is every reason to believe an alder chipping industry will develop.

4.5 UTILIZATION INFORMATION GAPS

Information presented in this section indicates that both an International and U.S. Pacific Northwest market exists for alder products. Considerable technical information has been developed, largely in the U.S. concerning specifications prices and other market details. Development of the resource in B.C. appears to have been limited by lesser size and it not being as conspicuous as in the Pacific Northwest.

Opportunities for primary manufacture appear to be well known and while interest is keen a combination of offered prices and inadequate supply information appear to be impeding increased utilization. Assuming that market prices will be attractive at some future date, utilization would be expedited by increased information on stand locations, quality, and accessibility.

Some information is available from the U.S. on harvesting hardwoods and alder, but other than minor trade journal articles, the techniques and technology that could be used or developed in B.C. have not been documented. This appears to merit investigation as does the role of harvesting timing and techniques with respect to regeneration and management objectives.

5. ENERGY POTENTIAL AND WASTE

5.1 BIOMASS

Evans (1974) suggested fast growing plantations as a potential source of energy. Howlett and Gormache (1977) discussed the silvicultural biomass farm using alder and other short rotation species. This was followed by Smith (1978) who discussed the energy plantation concept for alder at the 1978 symposium. He concluded that too much land would be required for the electricity resulting. Jones (1979) considered generating electricity at four sites on Vancouver Island using logging waste, precommercial thinnings and alder. While the results compared favourably with the cost of coal generation, they were premised on the availability of large amounts of "cheap" logging waste and only small amounts of alder.

Zavitkovski and Stevens (1972) described the primary productivity of red alder ecosystems and indicate biomass is at a maximum by age 10 to 15 years and harvesting should occur before age 20. Smith and DeBell (1974) outline the effects of stand density on the biomass of red alder. They noted large variations in tree size and that the biomass of fully stocked stands were associated with differences in stand density.

Recently, Helgerson et al (1988) have developed equations for estimating the above ground biomass in young Douglas fir and red alder plantations in Western Oregon.

5.2 BIOMASS ENERGY POTENTIAL

Little potential currently exists for the direct use of alder for energy other than the firewood market. Without industrial waste that has

accumulated as a by-product of alder utilization, the cost of extraction exceeds available alternatives.

In the case of firewood, low quality logs that bring low prices as industrial wood can be diverted into firewood and produce additional revenue rather than being left in the woods. Two conditions which favour the extraction and use of these logs are the existence of markets adjacent to the stands being harvested and that the stand has both some high quality wood and some low quality wood and/or alder. Logs such as low grade Douglas fir which would only command $20 to $25 per m^3 in the log market can be converted into firewood (along with alder) which sells, for example, in the Victoria area for $40 to $50 per m^3 on a delivered basis.

5.3 WASTE ENERGY POTENTIAL

Mill wastes due to the small volume of current production are not a significant potential source of energy. While some are utilized as firewood, most are disposed of by burning or landfill. Even to the small mills (current production), this is considered a problem and increases in production will exacerbate the problem. Currently, little if any are used for hog fuel.

Should a market for alder pulpchips develop, moderate volumes of "barky" hog fuel would be available at strategic coast locations. At such time, one consideration would be to look at the B.C. Hydro "co-generation" program which is being developed to utilize industrial wood waste.

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APPENDICES

APPENDIX 1. Selected average yields of alder, B.C. Coast, as reported by Smith (1978)

Site Class	Age Class	Alder plus conifer[1]		Alder plus deciduous[1]	
		Number of plots	Cubic foot volume 7.1"+	Number of plots	Cubic foot volume 7.1"+
1	30	2	5,829	5	3,773
	50	2	5,037	5	4,440
	70	2	6,134	1	5,455
		6		11	
2	10	-	--	3	950
	30	14	4,334	25	3,126
	50	13	4,963	26	4,242
	70	6	4,618	7	3,382
	90	9	6,290	5	4,117
		42		66	
3	10	2	720	9	2,188
	30	12	3,039	15	2,046
	50	4	3,932	3	4,531
	70	2	2,998	3	3,145
	90	1	6,609	-	--
		21		30	

1. B.C. Forest Service estimates for the south coast of B.C. for total cubic foot volume between a 1-foot stump and a 4-inch top dib, less decay only, in trees 7.1 inches and larger in dbh, for good, medium, and poor sites.

APPENDIX 2. Individual tree volume table reported in FRDA Manual: "Managing your Woodland" (1988) as calculated using Demaerschalk & Kozak (1977) equations.

INDIVIDUAL TREE VOLUME TABLE
(Gross Merchantable Volume in Cubic Metres)

RED ALDER

Stump Height = 30 cm
Top Diameter = 10 cm

DBH (cm)	TREE HEIGHT (METRES) 10	15	20	25	30	35	40	45
15	.06	.09	.12	.15	.19	.22	.25	.28
20	.13	.19	.25	.31	.37	.44	.50	.56
25	.20	.30	.40	.50	.60	.70	.80	.90
30	.30	.43	.57	.71	.85	1.0	1.1	1.3
35	.40	.58	.77	.96	1.2	1.3	1.5	1.7
40	.52	.75	.99	1.2	1.5	1.7	2.0	2.2

Stump Height = 30 cm
Top Diameter = 15 cm

20	.09	.14	.18	.23	.27	.32	.37	.41
25	.18	.27	.35	.44	.53	.62	.71	.80
30	.28	.41	.54	.67	.81	.94	1.1	1.2
35	.39	.56	.74	.93	1.1	1.3	1.5	1.7
40	.51	.73	.97	1.2	1.4	1.7	1.9	2.2

Stump Height = 30 cm
Top Diameter = 10 cm & 15 cm Combined

45	.64	.92	1.2	1.5	1.8	2.1	2.4	2.7
50	.79	1.1	1.5	1.8	2.2	2.6	2.9	3.3
55		1.3	1.8	2.2	2.6	3.0	3.5	3.9
60		1.6	2.1	2.6	3.1	3.6	4.0	4.5
65		1.8	2.4	3.0	3.5	4.1	4.7	5.2
70		2.1	2.7	3.4	4.0	4.6	5.3	5.9
75		2.4	3.1	3.8	4.5	5.2	5.9	6.7
80		2.6	3.4	4.2	5.0	5.8	6.6	7.4
85		2.9	3.8	4.7	5.6	6.4	7.3	8.2
90		3.2	4.2	5.1	6.1	7.1	8.0	9.0
95		3.5	4.6	5.6	6.7	7.7	8.8	9.8

APPENDIX 3. Inventory Statistics as reported by MacPherson (1980)

LOCATION OF COASTAL
HARDWOOD SPECIES – VANCOUVER PORTION
VOLUME (17.5 cm + dbh – close utilization less decay)
(100s of m^3)

PSYU	Alder	Cottonwood	Maple	Birch	Aspen	Total
Dewdney	525	525	187	479	–	1,716
Kingcome	5,031	5,141	71	90	428	10,761
Nootka	1,410	7	52	–	–	1,469
Quadra	1,428	493	748	48	–	2,717
Soo	572	1,659	378	587	–	3,196
Vancouver	368	144	572	18	–	1,102
Regulated	30	2	2	–	–	34
Unregulated	231	–	62	10	–	303
Sub-total	9,595	7,971	2,072	1,232	428	21,298
TFL including temporary tenures, but excluding Crown Grants in Schedule 'A'	9,329	948	4,281	10	–	14,568
Temporary Tenures	1,441	673	554	104	–	2,772
Crown Grants including those in TFL Schedule 'A'	37,117	1,190	3,904	799	–	43,010
Sub-total	47,887	2,811	8,739	913	–	60,350
Total	57,482	10,782	10,811	2,145	428	81,648

LOCATION OF COASTAL HARDWOOD SPECIES – PRINCE RUPERT PORTION VOLUME (22.5 cm + dbh – close utilization less decay) (100s of m^3)

PSYU	Alder	Cottonwood	Maple	Birch	Aspen	Total
Dean	5,790	5,968	–	726	1	12,485
Hecate	9,165	7,812	–	226	308	17,511
Queen Charlotte	3,173	–	–	–	–	3,173
Rivers Inlet	1,456	2,362	–	–	–	3,818
Unregulated	72	106	–	1	–	179
Sub-total	19,656	16,248	–	953	309	37,166
TFL including temporary tenures, but excluding Crown Grants in Schedule 'A'	1,349	13,983	–	121	1,169	16,622
Temporary Tenures	1,183	1,863	–	52	–	3,098
Crown Grants including those in TFL Schedule 'A'	642	4,237	–	52	35	4,966
Sub-total	3,174	20,083	–	225	1,204	24,686
Total	22,830	36,331	–	1,178	1,513	61,852
					VANCOUVER	81,648
					GRAND TOTAL COAST	143,500

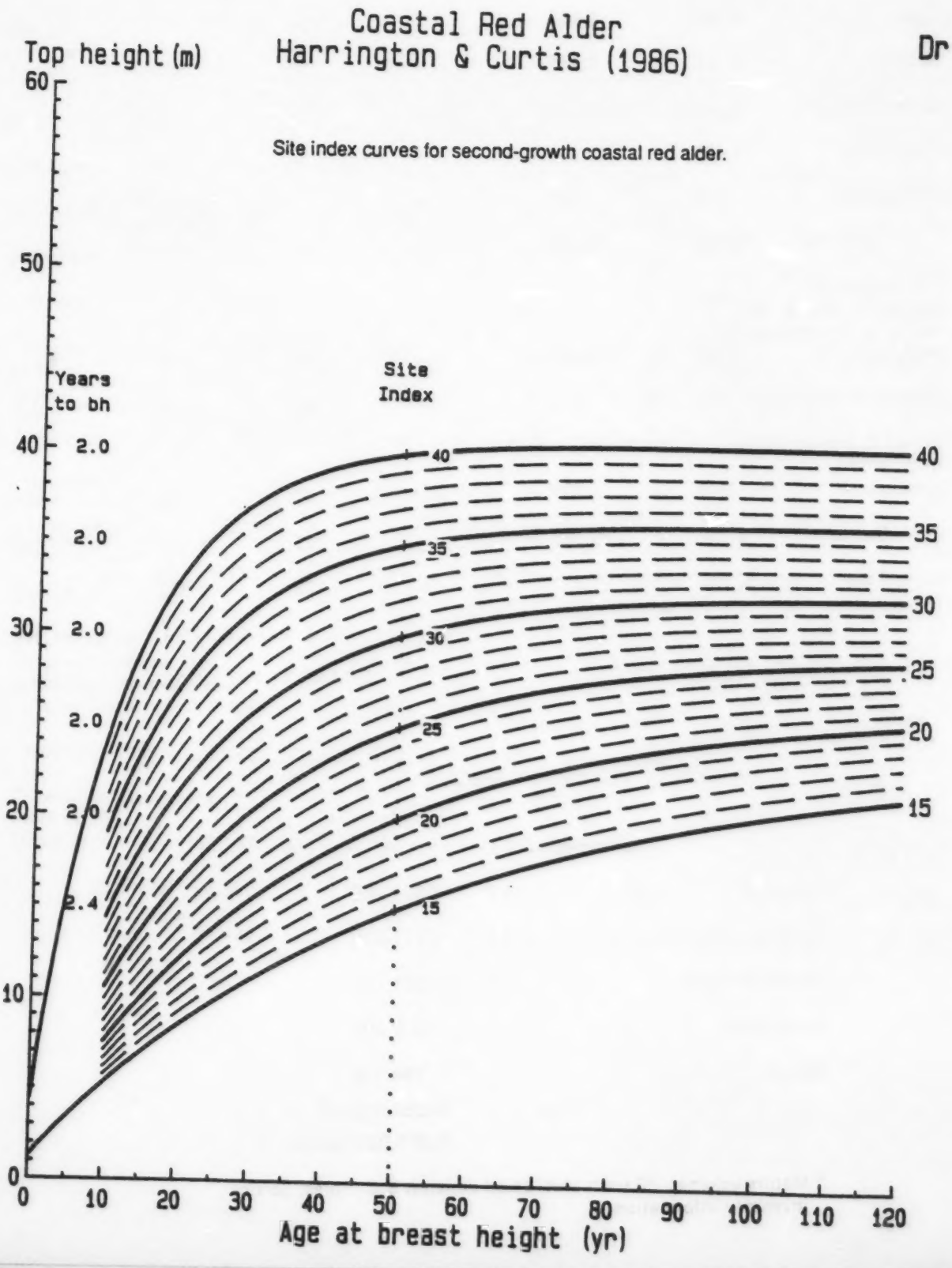
HARDWOOD VOLUME BY SPECIES* B.C. COAST

(cubic metres)

Red alder	8,031,200
Black cottonwood	4,711,300
Broadleaf maple	1,081,100
White birch	332,300
Aspen	194,100
Total	14,350,000 m^3 (5,071,000 cunits)

* Mature volumes, 80 years plus, based on latest B.C. Forest Service inventory information.

APPENDIX 4. Site index curves and site index table for 2nd growth coastal red alder after Harrington and Curtis (1986) as reported by Mitchell and Polsson (1988)



Site index table for second-growth coastal red alder

Dr

Age ♀ bh (years)	Site index: top height (m) ♀ breast height age 50 (Harrington & Curtis 1986)																				Age ♀ bh (years)
	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
	Top height (m) ◄																				
10	7.6	8.1	8.6	9.3	9.9	10.5	11.2	11.9	12.7	13.5	14.3	15.2	16.1	17.0	18.0	19.0	20.0	21.1	22.1	23.3	24.4	10
11	8.1	8.6	9.2	9.9	10.5	11.2	12.0	12.7	13.5	14.3	15.2	16.1	17.0	18.0	19.0	20.0	21.1	22.2	23.3	24.5	25.6	11
12	8.6	9.2	9.8	10.5	11.2	11.9	12.7	13.4	14.3	15.1	16.0	17.0	17.9	19.0	20.0	21.0	22.1	23.2	24.4	25.6	26.7	12
13	9.0	9.7	10.3	11.0	11.8	12.5	13.3	14.1	15.0	15.9	16.8	17.8	18.8	19.8	20.9	22.0	23.1	24.2	25.4	26.6	27.8	13
14	9.5	10.2	10.9	11.6	12.3	13.1	14.0	14.8	15.7	16.6	17.6	18.6	19.6	20.7	21.7	22.9	24.0	25.1	26.3	27.5	28.7	14
15	10.0	10.7	11.4	12.1	12.9	13.7	14.6	15.5	16.4	17.3	18.3	19.3	20.4	21.5	22.6	23.7	24.8	26.0	27.2	28.4	29.6	15
16	10.4	11.1	11.9	12.7	13.5	14.3	15.2	16.1	17.0	18.0	19.0	20.0	21.1	22.2	23.3	24.5	25.6	26.8	28.0	29.2	30.4	16
17	10.8	11.6	12.3	13.2	14.0	14.8	15.7	16.7	17.6	18.6	19.6	20.7	21.8	22.9	24.0	25.2	26.4	27.5	28.8	30.0	31.2	17
18	11.2	12.0	12.8	13.6	14.5	15.4	16.2	17.2	18.2	19.2	20.3	21.3	22.4	23.6	24.7	25.9	27.1	28.2	29.5	30.7	31.9	18
19	11.7	12.4	13.2	14.1	15.0	15.9	16.8	17.8	18.8	19.8	20.9	21.9	23.0	24.2	25.3	26.5	27.7	28.9	30.1	31.4	32.6	19
20	12.1	12.9	13.7	14.6	15.4	16.4	17.3	18.3	19.3	20.3	21.4	22.5	23.6	24.8	25.9	27.1	28.3	29.5	30.7	32.0	33.2	20
21	12.4	13.3	14.1	15.0	15.9	16.8	17.8	18.8	19.8	20.9	21.9	23.0	24.2	25.3	26.5	27.7	28.9	30.1	31.3	32.5	33.7	21
22	12.8	13.6	14.5	15.4	16.3	17.3	18.3	19.3	20.3	21.4	22.5	23.6	24.7	25.9	27.0	28.2	29.4	30.6	31.8	33.0	34.3	22
23	13.2	14.0	14.9	15.8	16.7	17.7	18.7	19.7	20.8	21.8	22.9	24.0	25.2	26.3	27.5	28.7	29.9	31.1	32.3	33.5	34.7	23
24	13.5	14.4	15.3	16.2	17.2	18.1	19.1	20.2	21.2	22.3	23.4	24.5	25.6	26.8	28.0	29.2	30.4	31.5	32.8	34.0	35.2	24
25	13.9	14.7	15.6	16.6	17.5	18.5	19.6	20.6	21.6	22.7	23.8	24.9	26.1	27.3	28.4	29.6	30.8	32.0	33.2	34.4	35.6	25
26	14.2	15.1	16.0	17.0	17.9	18.9	19.9	21.0	22.0	23.1	24.2	25.4	26.5	27.7	28.8	30.0	31.2	32.4	33.6	34.8	36.0	26
27	14.5	15.4	16.4	17.3	18.3	19.3	20.3	21.4	22.4	23.5	24.6	25.8	26.9	28.1	29.2	30.4	31.6	32.8	33.9	35.2	36.3	27
28	14.8	15.8	16.7	17.7	18.6	19.7	20.7	21.7	22.8	23.9	25.0	26.1	27.2	28.4	29.6	30.8	31.9	33.1	34.2	35.5	36.7	28
29	15.1	16.1	17.0	18.0	19.0	20.0	21.0	22.1	23.2	24.3	25.4	26.5	27.6	28.8	29.9	31.1	32.3	33.4	34.6	35.8	37.0	29
30	15.4	16.4	17.3	18.3	19.3	20.3	21.4	22.4	23.5	24.6	25.7	26.8	28.0	29.1	30.3	31.4	32.6	33.7	34.9	36.1	37.2	30
31	15.7	16.7	17.6	18.6	19.6	20.7	21.7	22.8	23.8	24.9	26.0	27.2	28.3	29.4	30.6	31.7	32.9	34.0	35.2	36.4	37.5	31
32	16.0	17.0	17.9	18.9	19.9	21.0	22.0	23.1	24.2	25.2	26.4	27.5	28.6	29.7	30.9	32.0	33.2	34.3	35.5	36.7	37.8	32
33	16.3	17.3	18.2	19.2	20.2	21.3	22.3	23.4	24.5	25.5	26.7	27.8	28.9	30.0	31.1	32.3	33.4	34.5	35.7	36.8	38.0	33
34	16.6	17.5	18.5	19.5	20.5	21.6	22.6	23.7	24.7	25.8	26.9	28.0	29.2	30.3	31.4	32.5	33.7	34.8	35.9	37.1	38.2	34
35	16.8	17.8	18.8	19.8	20.8	21.8	22.9	24.0	25.0	26.1	27.2	28.3	29.4	30.5	31.6	32.8	33.9	35.0	36.1	37.3	38.4	35
36	17.1	18.1	19.0	20.1	21.1	22.1	23.2	24.2	25.3	26.4	27.5	28.6	29.7	30.8	31.9	33.0	34.1	35.2	36.3	37.4	38.5	36
37	17.3	18.3	19.3	20.3	21.3	22.4	23.4	24.5	25.5	26.6	27.7	28.8	29.9	31.0	32.1	33.2	34.3	35.4	36.5	37.6	38.7	37
38	17.6	18.5	19.5	20.6	21.6	22.6	23.7	24.7	25.8	26.9	27.9	29.0	30.1	31.2	32.3	33.4	34.5	35.6	36.7	37.8	38.8	38
39	17.8	18.8	19.8	20.8	21.8	22.9	23.9	25.0	26.0	27.1	28.2	29.2	30.3	31.4	32.5	33.6	34.7	35.7	36.8	37.9	39.0	39
40	18.0	19.0	20.0	21.0	22.1	23.1	24.1	25.2	26.2	27.3	28.4	29.4	30.5	31.6	32.7	33.7	34.8	35.9	37.0	38.1	39.1	40
41	18.2	19.2	20.2	21.3	22.3	23.3	24.4	25.4	26.4	27.5	28.6	29.6	30.7	31.8	32.8	33.9	35.0	36.0	37.1	38.2	39.2	41
42	18.5	19.5	20.5	21.5	22.5	23.5	24.6	25.6	26.7	27.7	28.8	29.8	30.9	31.9	33.0	34.1	35.1	36.2	37.2	38.3	39.4	42
43	18.7	19.7	20.7	21.7	22.7	23.7	24.8	25.8	26.8	27.9	28.9	30.0	31.0	32.1	33.2	34.2	35.3	36.3	37.4	38.4	39.5	43
44	18.9	19.9	20.9	21.9	22.9	23.9	25.0	26.0	27.0	28.1	29.1	30.2	31.2	32.3	33.3	34.3	35.4	36.4	37.5	38.5	39.6	44
45	19.1	20.1	21.1	22.1	23.1	24.1	25.2	26.2	27.2	28.2	29.3	30.3	31.4	32.4	33.4	34.5	35.5	36.5	37.6	38.6	39.6	45
46	19.3	20.3	21.3	22.3	23.3	24.3	25.3	26.4	27.4	28.4	29.4	30.5	31.5	32.5	33.6	34.6	35.6	36.6	37.7	38.7	39.7	46
47	19.5	20.5	21.5	22.5	23.5	24.5	25.5	26.5	27.5	28.6	29.6	30.6	31.6	32.7	33.7	34.7	35.7	36.7	37.8	38.8	39.8	47
48	19.6	20.7	21.6	22.7	23.7	24.7	25.7	26.7	27.7	28.7	29.7	30.7	31.8	32.8	33.8	34.8	35.8	36.8	37.8	38.9	39.9	48
49	19.8	20.8	21.8	22.8	23.8	24.8	25.8	26.9	27.9	28.9	29.9	30.9	31.9	32.9	33.9	34.9	35.9	36.9	37.9	38.9	39.9	49
50	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0	50
51	20.2	21.2	22.2	23.2	24.2	25.1	26.2	27.1	28.1	29.1	30.1	31.1	32.1	33.1	34.1	35.1	36.1	37.1	38.1	39.1	40.1	51
52	20.3	21.3	22.3	23.3	24.2	25.2	26.3	27.2	28.3	29.3	30.2	31.2	32.2	33.2	34.2	35.2	36.2	37.1	38.1	39.1	40.1	52
53	20.5	21.5	22.5	23.5	24.5	25.4	26.4	27.4	28.4	29.4	30.4	31.3	32.3	33.3	34.3	35.2	36.2	37.2	38.2	39.2	40.2	53
54	20.7	21.7	22.6	23.6	24.6	25.6	26.6	27.5	28.5	29.5	30.5	31.4	32.4	33.4	34.3	35.3	36.3	37.3	38.2	39.2	40.2	54
55	20.8	21.8	22.8	23.8	24.7	25.7	26.7	27.7	28.6	29.6	30.6	31.5	32.5	33.5	34.4	35.4	36.4	37.2	38.3	39.3	40.2	55
56	21.0	22.0	22.9	23.9	24.9	25.8	26.8	27.8	28.7	29.7	30.7	31.6	32.6	33.5	34.5	35.5	36.4	37.4	38.3	39.3	40.3	56
57	21.1	22.1	23.1	24.1	25.0	26.0	26.9	27.9	28.9	29.8	30.8	31.7	32.7	33.6	34.6	35.5	36.5	37.4	38.4	39.4	40.3	57
58	21.2	22.2	23.2	24.2	25.1	26.1	27.1	28.0	29.0	29.9	30.9	31.8	32.7	33.7	34.6	35.6	36.5	37.4	38.4	39.4	40.3	58
59	21.4	22.4	23.3	24.3	25.3	26.2	27.2	28.1	29.1	30.0	30.9	31.9	32.8	33.8	34.7	35.6	36.6	37.5	38.5	39.4	40.4	59
60	21.5	22.5	23.5	24.4	25.4	26.3	27.3	28.2	29.1	30.1	31.0	31.9	32.9	33.8	34.7	35.7	36.6	37.6	38.5	39.5	40.4	60
61	21.7	22.6	23.6	24.6	25.5	26.4	27.4	28.3	29.2	30.2	31.1	32.0	32.9	33.9	34.8	35.7	36.7	37.6	38.5	39.5	40.4	61
62	21.8	22.8	23.7	24.7	25.6	26.5	27.5	28.4	29.3	30.2	31.2	32.1	33.0	33.9	34.8	35.8	36.7	37.6	38.6	39.5	40.5	62
63	21.9	22.9	23.8	24.8	25.7	26.6	27.6	28.5	29.4	30.3	31.2	32.1	33.1	34.0	34.9	35.8	36.7	37.7	38.6	39.5	40.5	63
64	22.0	23.0	23.9	24.9	25.8	26.7	27.7	28.6	29.5	30.4	31.3	32.2	33.1	34.0	34.9	35.9	36.8	37.7	38.6	39.6	40.5	64
65	22.1	23.1	24.0	25.0	25.9	26.8	27.8	28.7	29.6	30.5	31.4	32.3	33.2	34.1	35.0	35.9	36.8	37.7	38.7	39.6	40.5	65
66	22.3	23.2	24.2	25.1	26.0	26.9	27.8	28.7	29.6	30.5	31.4	32.3	33.2	34.1	35.0	35.9	36.8	37.7	38.7	39.6	40.5	66
67	22.4	23.3	24.3	25.2	26.1	27.0	27.9	28.8	29.7	30.6	31.5	32.4	33.3	34.2	35.1	36.0	36.9	37.8	38.7	39.6	40.6	67
68	22.5	23.4	24.4	25.3	26.2	27.1	28.0	28.9	29.8	30.7	31.5	32.4	33.3	34.2	35.1	36.0	36.9	37.8	38.7	39.6	40.6	68
69	22.6	23.5	24.5	25.4	26.3	27.2	28.1	29.0	29.8	30.7	31.6	32.5	33.4	34.2	35.1	36.0	36.9	37.8	38.7	39.7	40.6	69
70	22.7	23.6	24.6	25.5	26.4	27.3	28.1	29.0	29.9	30.8	31.6	32.5	33.4	34.3	35.2	36.0	36.9	37.8	38.8	39.7	40.6	70
71	22.8	23.7	24.6	25.6	26.4	27.3	28.2	29.1	30.0	30.8	31.7	32.6	33.4	34.3	35.2	36.1	37.0	37.9	38.8	39.7	40.6	71
72	22.9	23.8	24.7	25.6	26.5	27.4	28.3	29.1	30.0	30.9	31.7	32.6	33.5	34.3	35.2	36.1	37.0	37.9	38.8	39.7	40.6	72
73	23.0	23.9	24.8	25.7	26.6	27.5	28.4	29.2	30.1	30.9	31.8	32.6	33.5	34.4	35.2	36.1	37.0	37.9	38.8	39.7	40.6	73
74	23.1	24.0	24.9	25.8	26.7	27.5	28.4	29.3	30.1	31.0	31.8	32.7	33.5	34.4	35.3	36.1	37.0	37.9	38.8	39.7	40.6	74
75	23.2	24.1	25.0	25.9	26.7	27.6	28.5	29.3	30.2	31.0	31.9	32.7	33.6	34.4	35.3	36.2	37.0	37.9	38.8	39.7	40.7	75
Years to bh	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Years to bh

APPENDIX 5. Selected red alder stand yield tables; derived from Chambers (1983), metric equivalent.

RED ALDER STAND YIELDS

(Gross, total stem, all trees 17.5 cm and larger)

GOOD SITE (Site Index 30.5 m @ 50 years)

TOTAL AGE (years)	OVERSTOCKED* VOL (m3/ha)	OVERSTOCKED* AVERAGE STD DIA. (cm)	OVERSTOCKED* NO. STEMS (trees/ha)	FULLY STOCKED VOL (m3/ha)	FULLY STOCKED AVERAGE STD DIA. (cm)	FULLY STOCKED NO. STEMS (trees/ha)
25	202	23	524	170	23	422
30	264	24	585	221	24	474
35	326	25	625	272	25	509
40	388	26	647	322	26	529
45	448	27	659	371	28	541
50	507	29	659	418	29	564
55	563	30	650	463	30	538
60	618	31	635	505	31	526

TOTAL AGE (years)	UNDERSTOCKED VOL (m3/ha)	UNDERSTOCKED AVERAGE STD DIA. (cm)	UNDERSTOCKED NO. STEMS (trees/ha)	LOW STOCKING VOL (m3/ha)	LOW STOCKING AVERAGE STD DIA. (cm)	LOW STOCKING NO. STEMS (trees/ha)
25	138	23	329	106	24	240
30	178	24	370	135	25	269
35	218	26	398	164	26	291
40	256	27	415	191	27	306
45	293	28	425	216	28	314
50	329	29	427	240	29	316
55	362	30	425	261	30	316
60	392	31	420	279	31	311

* Based on Percent Normal Basal Area
Overstocked = 120%, Fully Stocked = 100%,
Understocked = 80%, Low Stocking = 60%

MEDIUM SITE (Site Index 21.3 m @ 50 years)

TOTAL AGE (years)	OVERSTOCKED VOL (m3/ha)	OVERSTOCKED AVERAGE STD DIA. (cm)	OVERSTOCKED NO. STEMS (trees/ha)	FULLY STOCKED VOL (m3/ha)	FULLY STOCKED AVERAGE STD DIA. (cm)	FULLY STOCKED NO. STEMS (trees/ha)
25	87	21	378	74	22	304
30	126	22	447	106	23	361
35	165	23	494	138	24	400
40	204	24	526	169	25	425
45	241	25	543	198	26	442
50	276	26	551	226	27	450
55	310	27	548	252	28	450
60	342	28	541	275	29	442

TOTAL AGE (years)	UNDERSTOCKED VOL (m3/ha)	UNDERSTOCKED AVERAGE STD DIA. (cm)	UNDERSTOCKED NO. STEMS (trees/ha)	LOW STOCKING VOL (m3/ha)	LOW STOCKING AVERAGE STD DIA. (cm)	LOW STOCKING NO. STEMS (trees/ha)
25	62	22	235	49	22	170
30	86	23	279	66	23	203
35	110	24	311	83	24	225
40	134	25	331	99	25	242
45	155	26	343	113	26	252
50	175	27	351	125	27	257
55	193	28	351	134	28	259
60	208	29	348	141	29	257